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The Relationship Between Physical Activity and Flexibility

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Physical Activity and Flexibility

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ABSTRACT

The purpose of this study was to determine if a relationship existed between flexibility and physical activity levels. Subjects included 128 male (n=64) and female (n=64) volunteers, 19 to 55 years of age. All subjects completed a physical activity questionnaire (which differentiated between work, sport, leisure and total physical activity) and a series of five flexibility tests. Four of the five flexibility tests were completed with the use of a goniometer which measured shoulder flexion, hip flexion, knee flexion and ankle dorsiflexion. The sit and reach test was used to assess hamstring-lumbar flexibility. After analyzing the data by using Pearson correlation coefficients, a relationship did not exist between total flexibility and physical activity. However, 10 significant relationships were discovered. Hip flexion measures, when correlated to the leisure physical activity index had a correlation coefficient of r=0.195. Sit and reach correlated to the leisure index and total physical activity (r=0.222 and r=0.208, respectively). Weight, age and gender had negative, significant relationships to total flexibility (r=-0.251, r=-0.188 and r=-0.400, respectively). Total flexibility correlated to shoulder flexion, ankle dorsiflexion, hip flexion and sit and reach scores (r=0.598, r=0.479, r=0.732 and r=0.776, respectively). All values were significant at $p \leq 0.05$. In conclusion, the subjects in this study demonstrated that physical activity (whether it was on the job, during leisure time, taking part in an organized sport or all three indices combined) did not correlate to the amount of total flexibility they possessed.

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CHAPTER I

INTRODUCTION AND JUSTIFICATION

It has been determined that flexibility, a joint's range of motion (ROM), is an important component of health physical fitness. Many benefits may be gained by incorporating a good stretching regimen into a regular exercise program. Stretching exercises may increase the length of connective tissues, decrease the amount of joint stiffness and increase ROM, therefore helping to prevent or alleviate joint soreness, muscle cramps and strains. Ekstrand, Gillquist, Moller and Oberg (1985) suggest that poor flexibility can lead to muscle rupture and tendinitis, and causes less than adequate performance in sports that require sufficient amounts of joint ROM. It is believed that performing static stretches can help reduce chronic muscle soreness and even, in some instances, relieve shin splints. Stretching has been known to help women decrease the discomfort associated with painful menstrual cycles (Corbin & Lindsey, 1994). Regular flexibility programs have also been shown to improve the mobility of the spinal column in older adults, making it possible for them to continue driving cars, tying their shoes, reaching, twisting and other daily activities and movements. Considering these benefits, it is evident why flexibility is important. There is a question that has yet to be answered: Is there a relationship between the type of physical activity individuals are involved in and the amount of flexibility they may possess?

Physical activity can be divided into two different categories. Occupational physical activity (OPA) is all activity that is non-leisure in nature. This consists of what

individuals do for their profession, as well as the sort of household work they do. Leisure-time physical activity (LTPA) pertains to structured exercise programs, organized or recreational sports, and even active hobbies (e.g. hiking, canoeing, or skiing) people enjoy taking part in on their free time. The later form of activity is the one with the most emphasis placed on it due to the increased awareness that leisure activity is highly associated with having a healthy lifestyle (Lamb & Brodie, 1990). Risk factors for heart disease are greatly associated with physical inactivity. Klesges, Eck, Isbell, Fulliton and Hanson (1991) discovered that LTPA results in a decrease in body fatness, resting heart rate and blood pressure in both men and women.

Numerous studies have shown relationships between LTPA and flexibility. Corbin and Noble (1980) reported that increased ROM is related to a higher level of performance. Lee, Etnyre, Poindexter, Sokol and Toon (1989) expanded on Corbin and Noble's study to identify if a relationship existed between flexibility and sport-specific skills. They discovered that there was such a relationship. Male volleyball players with greater hip flexibility had higher vertical jumps, however female volleyball players with the greatest vertical jumps had the least hip flexibility. These researchers concluded that greater hip flexibility might benefit men more than women for jumping ability. Another study noted that joggers, weight trainers, aerobic dancers and those who participated in an eight week life saving course increased their post-test flexibility scores more so than individuals enrolled in a non-active course (Ford, Puckett, Blessing & Tucker, 1989). Two studies that looked at postmenopausal women (Caballero et al., 1996) and elderly women

(Voorrips, Lemmink, Van Heuvelen, Bult & Van Staveren, 1993) concluded that those who participated in moderate physical activity and those who perceived themselves as being more active, respectively, have significantly better joint ROM. It is evident from past research that being active in LTPA can influence flexibility positively.

There has been a lack of research in the area of OPA as it relates to flexibility. Horowitz and Montgomery (1993) examined how Canadian fire fighters performed on tests that measured cardiovascular, flexibility and muscular endurance levels, as well as anthropometric assessments. They discovered that compared to the norms for the general Canadian population of similar age, the fire fighters were much more flexible. Do other active professions demonstrate the same results and, if so, is there a specific pattern of flexibility associated with the most actively used joints? This concept holds true for some athletes. There is greater flexibility in the wrists of shot-putters and discus throwers. Gymnasts have shown to be more flexible in the hips than ankles (Fox, Bowers & Foss, 1993). Flexibility is joint and movement specific. More studies should be conducted looking at occupations and flexibility relationships.

Researchers have used a variety of methods in the past to evaluate human physical activity levels. Such methods have included calorimetry, time-motion analysis, job classification, diaries, doubly labelled water, pedometers, electronic motion sensors and dietary assessment (LaPorte, Montoye & Caspersen, 1985). These methods tend to be time consuming, lengthy and, in some cases, expensive. Physical activity questionnaires are now the most popular, practical and simple techniques for such assessments. Today,

numerous questionnaires exist that consider LTPA only, OPA only, or a combination of the two. There are interviewer-administered questionnaires, but self-administered questionnaires are usually shorter. Although difficult to initially establish, reliability and validity measures do exist for the majority of these. It is important to remember that a questionnaire should yield similar results if given on two different occasions, and should measure actual LTPA or OPA (Lamb & Brodie, 1990). This study will determine individual physical activity levels, for both types of activity, through the use of a carefully selected, self-completed questionnaire.

Although many studies have considered the relationship between LTPA and flexibility, those that focus on OPA and its effects on joint ROM are limited. Therefore, the purpose of this study was to determine if a relationship existed between flexibility measurements and human physical activity levels, taking into account both LTPA and OPA.

STATEMENT OF PROBLEM

The purpose of this study was to determine if a relationship existed between flexibility measurements and physical activity levels. Both LTPA and OPA were addressed in a self-completed questionnaire.

DELIMITATIONS

Subjects that participated in the study included 128 healthy males (n=64) and females (n=64), ranging from 19 to 55 years of age. Subjects were recruited on a

volunteer basis. Participants varied in physical activity levels with no regular stretching programs six months prior to this study, had no musculoskeletal injuries or surgeries within six months prior to this study, were not experiencing joint effusion at the time of testing and females were not pregnant or post-partum. Physical activity levels and five different ROM measurements were studied.

LIMITATIONS

The physical activity questionnaire was self-completed, therefore, it was possible that a subject may not have been completely accurate in their responses. Tester error, as well as subjects' efforts may have been involved when recording measurements for the flexibility tests. Also, younger subjects possessed more joint ROM than older subjects.

HYPOTHESIS

It was hypothesized that a positive relationship exists between physical activity levels and flexibility measurements even though individuals did not implement regular stretching programs into their lives. The significance level was set at $p \leq 0.05$.

DEFINITION OF FUNCTIONAL TERMS

For clarity the following terms are defined:

CONCEPTUAL: **Exercise** - A subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective for the

improvement or maintenance of physical fitness (Caspersen, Powell & Christenson, 1985).

Flexibility - Range of motion (ROM) in a joint or group of joints (Corbin & Lindsey, 1994).

Goniometer - The most common instrument used to measure joint position and motion in the clinical setting (Norkin & White, 1995).

Goniometry - The measurement of angles created at human joints by the bones of the body (Norkin & White, 1995).

Physical Activity - Any bodily movement produced by skeletal muscles that results in energy expenditure (measured in kilocalories). Physical activity in daily life can include occupational, sports, conditioning, household, or other activities (Caspersen et al., 1985).

Physical Fitness - A set of characteristics that are either health- or skill-related which can be measured with specific tests (Caspersen et al., 1985).

Range of Motion (ROM) - The amount of motion available at a joint (Norkin &White, 1995).

Stretching (Flexibility) Exercises - Exercises used to increase the existing ROM at a joint by elongating muscles and other soft tissues (Corbin & Lindsey, 1994).

FUNCTIONAL: **Leisure-Time Physical Activity (LTPA)** - Physical activity that consists of structured exercise programs, organized or recreational sports, and active hobbies such as hiking, canoeing, or skiing.

Occupational Physical Activity (OPA) - All physical activity that is non-leisure in nature and consists of what individuals do for their profession and household work.

JUSTIFICATION

If the outcome of this study shows that a positive relationship exists between physical activity levels and flexibility measurements, then it is hoped to help people understand the importance of increasing their physical activity levels, on the job and during their leisure-time. In doing this, joint ROM may be affected positively, decreasing the risk of injury and increasing mobility levels as individuals get older. It may also have given some insight into how often an individual should stretch. The benefits of adequate flexibility levels are well known, but is being physically active enough to maintain the normal amounts of joint ROM, or is a daily stretching program necessary? Additionally, limited research has been completed on the topic of flexibility, as well as its relationship with physical activity. This study examined both of these much needed areas of interest.

CHAPTER II

REVIEW OF LITERATURE

In this chapter, past research in the area of physical activity and its observed effects on flexibility are reviewed. For the purpose of this study, flexibility as it relates to OPA and LTPA is discussed. Also, qualitative methods for assessing physical activity are reviewed as well as the reliability of goniometric measurements.

The Relationship Between Flexibility and OPA and LTPA

Little literature exists discussing how OPA and LTPA, as a whole, may influence an individual's joint ROM. What information was found on this topic was from studies investigating other areas. Horowitz and Montgomery (1993) compared the physical fitness level of Canadian fire fighters to a group of Canadian nonfire fighters of similar age and sex. They studied 1,303 male, Montreal fire fighters between the ages of 19 and 58 years. The Canadian Standardized Test of Fitness was utilized to test physical fitness levels by evaluating cardiovascular, flexibility and muscular endurance fitness, as well as anthropometric assessments. The authors used the sit and reach test to measure the flexibility of the fire fighters. They found that fire fighters possessed a greater degree of joint ROM than nonfire fighters. Statistical values were not provided in this study. The two authors never suggest why they felt this to be true.

Brownlie et al. (1985) performed a study in an effort to design a selection procedure for entry level fire fighters for the Vancouver Fire Department of British Columbia. The

subjects were a large group of applicants (n = 3,172), 16.4% of whom were selected for final review. All the candidates were taken through four groups of tests. In order, these tests were Gross Physical Elimination; Psychomotor, Flexibility and Strength Ranking; Obstacle Course; and Knowledge Tests. They had to pass one set of tests before moving to the next set. If applicants completed all four groups of tests, they were interviewed for possible hire. Flexibility tests assessed extent flexibility (an ergonomic analysis of reach height) and sit and reach flexibility. This study clarified the importance of flexibility for this occupation and is even used as a screening tool for selection. If a minimum amount of flexibility was not demonstrated, the candidate would not pass the first half of the screening process to become a fire fighter.

A study by Jones et al. (1993) documented the impact of past physical activity, current physical fitness and Army physical training on the incidence of injuries among new Army recruits. Subjects included 303 male Army Infantry trainees with a mean age of 19 years. The study was completed in two phases: baseline evaluation and follow-up. Baseline evaluation occurred when trainees arrived for duty, prior to the onset of any military training. A physical activity questionnaire was completed and METs (metabolic equivalents) were calculated as a scoring technique. Physical fitness measurements were also taken (body composition, flexibility, strength and cardiovascular). Follow-up consisted of training activities documentation (one unit emphasized running, while the other de-emphasized it). Both did training five days-per-week. The running group equaled 130 miles over 12 weeks and marched 68 miles, while the non-running group ran

56 miles and marched 121 miles. Results from the final Army physical fitness test were recorded. Trainees reported high self-rated physical activity levels (60.6% more active than "average" and only 9.9% inactive). Of the 303 subjects, 45.9% (139) sustained one or more injuries during the training. Trainees who rated themselves as less active than average or who exercised less were at significantly ($p \leq 0.05$) higher risk of injury than the more active trainees. The strongest and most significant association was between lower running frequency and increased incidence of injury. Flexibility demonstrated a significant ($p \leq 0.05$) U-shaped relationship with incidence of injury. Individuals at both extremes of flexibility were at more than two times greater risk that the "average" group for lower body injuries. Jones et al. (1993) concluded that stretching to increase flexibility is widely recommended to prevent injuries and that data to support this fact is lacking. The finding that both extremes of flexibility experience more injuries and its implications for the prevention and rehabilitation of injuries needs to be further studied.

Fox et al. (1993) provided some insight into the specificity of flexibility which could explain why some active occupations cause individuals to be more flexible in their most worked joints than those people who may only stretch that certain joint 20 minutes, five times a week. These authors discuss this specificity in terms of athletics. Shot-putters and discus throwers have more flexibility in their wrists than wrestlers do. Gymnasts have greater ROM in their hips than football players. Fox et al. Also suggested that flexibility is specific to the joints moved throughout full ROM the most. A gymnast has a great amount of hip flexibility, but below average ankle flexibility. Possibly, these ideas of

flexibility could be used to identify any trends where OPA and LTPA are concerned.

Lee et al. (1989) determined if a relationship existed between joint ROM and specific sport or motor skills by observing 24 male and 22 female members of the United States National Olympic Festival Volleyball teams during the summer of 1986. The standing and approach vertical jump tests were used to measure jumping performances. Transverse shoulder extension and hip flexion ROM was measured using a stainless steel goniometer. They found that the male volleyball players showed a significant and positive correlation between approach vertical jump and hip flexibility ($r=.42$, $p<0.03$). Female volleyball players showed a significant and negative correlation between standing vertical jump and hip flexibility ($r = -.54$, $p=0.009$) and between approach vertical jump and hip flexibility ($r = -.47$, $p=0.03$). A low, negative correlation existed between shoulder flexibility and both jumping conditions for both sexes ($r=-.27$ to $-.40$). Lee et al. (1989) concluded that the flexibility differences were related to the anatomical differences of the hip joint between the sexes and that increased hip joint ROM was more beneficial for the men for jumping ability. The authors suggested that further studies are needed to observe if these results are consistent with other elite athletes in volleyball and other sports.

Ford et al. (1989) performed a study to determine the effects of eight weeks of participation in an activity course (aerobic dance, jogging for fitness, swimming for fitness, life saving or weight training) on multiple measures of health-related fitness and psychological well-being. Subjects included 108 women from a large state university in the southeast United States with a mean age of 19.8 years. All subjects completed a

questionnaire consisting of demographic data and two psychological inventories. Four health-related fitness tests (step test, 60 second sit-up test, sit and reach and body composition) were administered to the group. Sit and reach procedures used for the study were created by the American Alliance of Health, Physical Education, Recreation and Dance. The two psychological tests and battery of fitness tests were given prior to and preceding the eight week course. They found that subjects in jogging, aerobic dance, weight-training and life saving showed a significant increase in flexibility scores, in comparison to individuals enrolled in non-active courses on the post-test after controlling for pre-test scores ($p<0.05$). The authors concluded that participation in some activity courses seem to influence flexibility and muscular endurance favorably, but not psychological well-being, cardiovascular fitness or body composition. Gains in physical fitness by those in the activity groups were probably specific to the movements performed in the different courses. The authors also suggest that participation in extracurricular activities may have influenced the gains.

Caballero et al. (1996) studied the nature of the relationships between physical activity and parameters related to bone metabolism (muscular strength, flexibility and changes in sex hormone binding globulin) in postmenopausal women. Subjects included 19 postmenopausal women with a mean age of 55.0 ± 8.0 years. They completed a medical and diet questionnaire and participated in a five month training period which included one hour of moderate physical exercise three days per week. Pre- and post-tests were completed for skinfolds, muscle strength and flexibility. Front and back flexibility

was measured by a device known as a flexibilimeter. Results showed significant changes in tricepital, subscapular and suprailiac skinfolds, as well as in muscle strength and flexibility in response to the training period. Pre measurements for front flexibility were 22.3 $\pm$ 10.3 cm, while post measurements were 48.1 $\pm$ 17.6 cm, p = .00005. Pre measurements for back flexibility were –0.1 $\pm$ 6.7 cm, while post measurements were 3.1 $\pm$ 2.6 cm, p = .0002. Caballero et al. (1996) concluded that flexibility increases were a beneficial effect of physical activity in this group.

Voorrips et al. (1993) performed a study to determine how elderly womens' true fitness level matched their own subjective results from a self-completed physical activity questionnaire. Fifty elderly women with a mean age of 71.5 $\pm$ 4.2 years participated in the study. The women completed a questionnaire about self-perceived physical health and fitness on the day prior to testing. On the day of testing, they each met with a physician to discuss possible problems on certain tests. They then performed a battery of physical fitness tests. Flexibility of the hip and spine were measured using a sit and reach test. The maximal reach out of three trials were recorded in centimeters. Flexibility of the shoulder joint was assessed by recording the movement of the handgrip on a rope when the subject moved her outstretched arms from the frontal side, over the head, to the dorsal side of the body. Results showed that body weight and body mass index, flexibility of hip and spine (sit and reach), and endurance on a walk test were significantly better in more active women. Flexibility of the hip and spine in the sedentary women (n=16) were 22.9 $\pm$ 8.9 cm, as opposed to 35.2 $\pm$ 8.7 cm in the high active women (n=19). Pearson correlation

coefficients showed that those with higher body weight had lower levels of flexibility in the shoulders and hip and spine. The questionnaire results showed that the more active women reported better condition on almost all aspects of physical fitness, most notably on flexibility, endurance and balance. Voorips et al. concluded that elderly women with a higher habitual physical activity as assessed by a questionnaire, have better results on tests of endurance and flexibility of the hip and spine, as well as lower body weights and body mass indexes. However, no significant effect was noticed on flexibility of the shoulder joint. The authors feel that daily living activities performed are enough to support the flexibility of the shoulder joint.

In a review article by Koutedakis (1995), a few studies in the area of seasonal training for athletes noted that little or no changes in flexibility are seen after long periods of training. An example was given that after a season of training and competition, female collegiate volleyball players demonstrated that ankle, hip and low back flexibility remained unchanged. The author suggests that, for athletes, training and competition alone will not improve joint ROM, but by including specific flexibility exercises, the athletes' flexibility measures will increase. The vast majority of the literature agrees that for the non-athlete, increasing physical activity levels will improve flexibility.

It is suggested that flexibility needs to be part of an exercise routine, however, little to no information has been examined to what relationship flexibility has with physical activity. The research that has been reviewed discusses a variety of different topics except the area needed for this study. Therefore, it is the purpose of this paper to study the

relationship between flexibility and physical activity.

Physical Activity Assessments

Social and physical scientists have tried for over 30 years to accurately assess human physical activity levels. According to Lamb and Brodie (1990), numerous methods exist, however, utilizing questionnaires seem to be the most popular and practical method. There are at least 38 different questionnaires designed to assess physical activity levels, Lamb and Brodie explain that many are interviewer-administered, while others are self-completed. The majority of questionnaires assess mainly LTPA, however, some evaluate OPA or a combination of the two.

These questionnaires usually require that the individual recall what physical activities they took part in over a certain period of time, depending on the questionnaire. They also must give the frequency and duration of each activity. This allows the tester to convert this information into some type of score or index of physical activity, which can then represent an estimate of the amount of energy expended (kcals or METS) averaged per day, week or month. The calculated activities can then be grouped into distinct categories, such as light, moderate, hard and very hard.
Other questionnaires simply rank the subjects on an ordinal scale or classify them into one of several summarized activity groups (Lamb & Brodie, 1990).

According to LaPorte et al. (1985), besides questionnaires, there are over 30 methods that can be used to assess physical activity. There are seven categories these

methods can be grouped in: calorimetry, job classification, surveys, physiologic markers (such as cardiorespiratory fitness or doubly-labeled water), behavioral observation, mechanical and electronic monitors and dietary measures. As a whole, these methods are time consuming, expensive, population specific and not practical to use for mass testing. Some of them such as direct calorimetry, are very precise, while others like movement sensors and doubly-labeled water procedures, are still in their experimental phase. Surveys are the most practical method for large-scale studies, although little is known about their reliability and validity.

Undoubtedly, the reliability and validity of physical activity questionnaires are of concern. Lamb and Brodie explain that for a questionnaire to be reliable, it should yield the same information from the same individuals on two different occasions and, at the same time, measure LTPA, OPA or both. Establishing reliability and validity has not always been done or it has been found to be a difficult process since there is no accepted gold standard for assessing physical activity. Measures associated with physical activity such as body composition, fitness level, activity and food diaries have been used to measure indirect or construct validity. A test-retest procedure is normally the best method to determine intratester or test-retest reliability. Even though reliability and validity is an important feature of a questionnaire, it is surprising to note that the most popular LTPA questionnaires, the Minnesota LTPA Questionnaire and the Paffenbarger Physical Activity Questionnaire, were not reported to be reliable until years after their first publication (Lamb & Brodie, 1990). Many researchers, including Jacobs et al. (1993), are evaluating

physical activity questionnaires for validity and reliability to make it easier for other researchers to choose the appropriate format for them.

This study will be utilizing the Baecke Questionnaire of Habitual Physical Activity to assess both LTPA and OPA. This is a 16 question, self-completed questionnaire consisting of three sections: physical activity at work, sport during leisure time, and physical activity during leisure time excluding sport. Baecke, Burema and Frijters (1982) investigated the construct validity of the self-administered questionnaire about habitual physical activity, as well as its test-retest reliability. Young males (n=139) and females (n=167) between the ages of 20 and 32 years participated in the study. The subjects completed the questionnaire at home, brought the completed form to a mobile research unit to be checked and had anthropometric measurements taken. Three months later, the subjects completed the questionnaire again to study the test-retest reliability. The original questionnaire consisted of 29 questions concerning occupation, movement, sport, leisure-time activities excluding sport and sleeping habits. Results of the study showed that construct validity was established through factor analysis by retaining the items that were well related to physical activity. Sixteen questions remained following this finding which now make up the questionnaire. The test-retest reliability of the work, sport and leisure indices were $r=0.88$, $r=0.81$ and $r=0.74$, respectively. Results were significant at the $p \leq 0.01$ level. Tables 1 and 2 summarize the reliability and validity results from other studies concerning the Baecke Physical Activity Questionnaire.

TABLE 1

Reliability Studies of the Baecke Physical Activity Questionnaire

Reference	Methods	Subjects	Results (r values)	
Baecke et al. (1982)	Relationships between first test and 3 month retest. Pearson correlations with no P value reported.	139 men and 167 women between ages of 20 to 32 years.	Work Index Sport Index Leisure Index	0.88 0.81 0.74
Jacobs, Ainsworth, Hartman & Leon (1993)	Relationships between first test and 1 month retest. Spearman correlations adjusted for age. $P<0.05$.	28 men and 50 women between the ages of 20 and 59 years.	Work Index Sports Index Leisure Index Total Index	0.78 0.90 0.86 0.93

TABLE 2

Validity Studies of the Baecke Physical Activity Questionnaire

Reference	Methods	Subjects	Results (r values)				
Richardson, Ainsworth, Jacobs & Leon (1995)	Relationship between the Baecke and peak oxygen consumption (VO2), % body fat (BF), Caltrac (CAL), and 48 hour activity diaries (PA). Pearson partial correlations adjusted for age. (* P<0.05).	28 men and 50 women university faculty, staff, and students ages 21 to 59 years.	Men	V02	BF	CAL	PA
			Sports	0.67*	-0.37	0.34	0.58*
			Leisure	0.13	-0.05	-0.05	0.37
			Total	0.57*	-0.30	0.24	0.59*
			Women				
			Sports	0.45*	-0.44*	0.24	0.24
			Leisure	0.38*	-0.51*	0.06	0.42*
			Total	0.46*	-0.51	0.19	0.33*
Jacobs, Ainsworth, Hartman & Leon (1993)	Relationship between the Baecke and maximal oxygen consumption (VO2), % body fat (BF), Caltrac (CAL;MET-min/d), and total 4 week activity history (PA;MET-min/d). Spearman correlations. (*P<0.05).	28 men and 50 women ages 20 to 59 years.		V02	BF	CAL	PA
			Total	0.54*	-0.49*	0.19	0.37*
			Work	0.23	-0.17	0.11	0.05
			Sport	0.52*	-0.35*	0.32*	0.40*
			Leisure	0.26*	-0.39*	0.01	0.28*

The Reliability of Goniometric Measurements

This study used goniometry as the preferred method for measuring joint ROM. It is a method of measurment primarily used by physical therapists to determine a patient's baseline level of joint ROM, prescribe the coarse of rehabilitation for that individual, as well as gauge and document their progress. Clinical physical therapists view the universal goniometer as the most practical and widely used instrument for measuring joint movements (Gajdosik & Bohannon, 1987). Reliability is the most important factor affecting objective goniometric measurments. A study by Boone et al. (1978) determined the intratester and intertester reliability of goniometric measurements. The study involved four physical therapists, each with varied experience in goniometry, who took six upper and lower extremity joint ROM measurements on 12 healthy, male volunteers. Each tester took three measurements per joint motion for each subject. The subjects were measured once a week for four weeks. Data analysis consisted of analysis of variance with repeated measures. Intertester reliability was greater for the upper extremity motions ($r = .86$) than for lower extremity motions ($r = .58$). This implies that there is less variability between measurements of the same joint by different testers for the upper extremity than for the lower extremity. Intratester reliability for the upper extremities was $r = .89$ and $r = .80$ for the lower extremities. This suggests that there is a good amount of agreement between measurements of the same joint by the same tester and is an indication that it is important to use the same tester when evaluating how a rehabilitation program is progressing.

Feedback was given to the participants of this study as to how their joint ROM's

compared to normative values. Norkin and White (1995) list the average ranges for various joint motions as stated by four different groups/organizations. For the purpose of this study, those average ROM's suggested by the American Academy of Orthopeadic Surgeons were used and are listed in Table 3.

Summary

Researchers agree that for the majority of people, increasing LTPA can have a direct impact on improving joint ROM. However, since physical inactivity during leisure time is becoming increasingly more common, OPA needs to be considered. Few researchers have examined how OPA may influence flexibility. The greatest benefit individuals will gain from improving and/or maintaining good levels of flexibility is the ability to better perform daily activities, to decrease their chances of developing back pain and to avoid disability all as they advance into older age.

It is difficult to qualitatively measure physical activity levels accurately in an individual, but it can be accomplished. There are a variety of methods that can perform such a task. The most practical is through the use of physical activity questionnaires. Questionnaires tend to be fast, simple and inexpensive, however, their reliability and validity are always questioned. More research is being completed to determine the reliability and validity of many physical activity questionnaires.

Numerous methods exist which measures an individual's joint ROM. The most preferred method is goniometry. Physical therapists goniometers daily in clinical, as well

TABLE 3

Average Joint Ranges of Motion Suggested by the American Academy of Orthopedic Surgeons

Joint	Motion	ROM (degrees)
Shoulder	Flexion	0 – 180
Hip*	Flexion	0 – 120
Knee	Flexion	0 – 135
Ankle	Dorsiflexion	0 – 20
Lumbar/Hamstrings**	Sit and Reach	Males – 1-3 inches Females – 1-5 inches

* Norms only found for hip flexion with a flexed knee.

**Norms taken from the American College of Sports Medicine (1995)

as research settings to determine baseline ROM measurments and for documentation purposes in an effort to assess progress. Reliability of goniometric measurements has been researched and is important to be aware of when using this technique.

CHAPTER III

METHODS

Preliminary Procedures

Subjects

One hundred-twenty eight individuals (64 males and 64 females) between the ages of 19 to 55 years volunteered to participate in this study. The subjects completed a physical activity questionnaire and a series of five flexibility tests at the University of Nebraska at Omaha's Exercise Physiology Laboratory. Subjects were not be permitted to take part in the study if they were pregnant or post-partum, experiencing joint edema, or if they had any musculoskeletal injuries or surgeries within the past six months of participation in the study. Subjects were not participating in a regular stretching program for six months prior to this study and were instructed to have no physical activity on their scheduled day prior to testing. All participants performed the same, timed warm-up prior to the flexibility testing.

Medical History and Informed Consent

This study was approved by the Institutional Review Board prior to its implementation. Each subject completed a medical history and informed consent form before participating in this study. The medical history determined if subjects qualified to participate in this study focusing on past musculoskeletal injuries and surgeries, pregnancy, joint inflammation at that time, as well as their stretching regimen for the past

six months. The consent form included an explanation of the study, purpose, procedures, risks, benefits, rights of the subject and confidentiality of the research obtained from the study.

Operational Procedures

Completion of the Physical Activity Questionnaire

The Baecke Questionnaire of Habitual Physical Activity (1982) was the tool used to assess physical activity levels for this study. It evaluated both LTPA and OPA and was self-completed. The time necessary to complete this questionnaire was approximately 10 minutes. The time frame of recall was considered usual activity with no specific time component. The Baecke Questionnaire consisted of three sections: work activity, sports activity and non-sports leisure activity. The majority of the questionnaire was scored on a five-point Likert scale, ranging from never to always or very often. Three additional questions required the number of months and hours per week or minutes per day of participation. Scoring of the questionnaire is as follows as described in Medicine and Science in Sports and Exercise (A Collection, 1997).

Work index = Mean score from occupational Likert scale questions one through eight
Note: Scoring for question one is:
1 = "Low level" occupations such as office or clerical work, driving, shopkeeping, teaching or studying
2 = "Middle level" occupations such as factory work, plumbing or carpentry
3 = "High level" occupations such as dock work or construction work.
Sports index = Mean score of questions 9 through 12
Note: Score for question 9 = Sum of [proportion of year of participation X

intensity code X time (duration)] for all activities. The intensity, duration and proportion codes can be found on the questionnaire.

Non-sports leisure = Mean score for questions 13 through 16.

Total score = work index + sports index + non-sports index.

Note: For questions 2 and 13, the Likert scale response is subtracted from six, The questionnaire has no unit of measure.
A score of 15 is the highest that can be achieved.

Numerous reliability and validity studies have been completed on this questionnaire.

General Measurements

Gender, age, weight and height was recorded for each subject for the purpose of subject demographics. Subjects were weighed in minimal clothing (shorts and a t-shirt) with no shoes using a Detecto Medical Scale to the nearest 0.1 kg. Height was determined using a medical stadiometer to the nearest 0. 5 cm.

Warm-Up

All subjects performed the same warm-up prior to the flexibility tests. Subjects walked for eight minutes at a self-selected pace on a Sensormedics 2000 treadmill in the Exercise Physiology Laboratory.

Flexibility Tests

A series of five ROM tests were performed by each subject. These tests were randomly chosen for each subject. Four of the five were completed with the use of a goniometer. The other was a sit and reach test. For the goniometry tests, three

measurements were taken for each active movement on the subjects dominant side of their body. An average of the two closest scores were recorded. A description of each measurement follows.

1.) SHOULDER FLEXION

Starting Position: The subject was in a supine position, with the knees flexed to flatten the lumbar spine. The shoulder was in 0 degrees of abduction, adduction and rotation. The forearm was in 0 degrees of supination and pronation so the palm of the hand faces the body.

Motion: Movement occurred in the sagittal plane around a medial-lateral axis.

End-Feel: The normal end-feel of the glenohumeral motion was firm because of tension in the posterior band of the coracohumeral ligament, the posterior joint capsule and the teres minor, teres major and infraspinatus muscles. The normal end-feel of the shoulder complex motion was firm because of tension in the latissimus dorsi muscle and the costosternal fibers of the pectoralis major muscle.

Goniometer Alignment: The center of the fulcrum of the goniometer was close to the acromial process. The proximal arm was aligned with the midaxillary line of the thorax. The distal arm was aligned with the lateral epicondyle of the humerus.

2.) HIP FLEXION

Starting Position: The subject was in a supine position, with the hip in 0 degrees

of abduction, adduction and rotation. The knee remained extended throughout the movement.

Motion: Movement occurred in the sagittal plane around a medial-lateral axis.

End-Feel: The end-feel was firm because of tension in the posterior joint capsule and the gluteus maximus.

Goniometer Alignment: The center of the fulcrum was placed over the lateral aspect of the hip joint using the greater trochanter of the femur for reference. The proximal arm was aligned with the lateral midline of the pelvis. The distal arm was aligned with the midline of the femur using the lateral epicondyle for reference.

3.) KNEE FLEXION

Starting Position: The subject was in the supine position with the knee in extension. Initially, the hip was in 0 degrees of extension, abduction and adduction, but as the knee began to flex, the hip also flexed.

Motion: Movement occurred in the sagittal plane around a medial-lateral axis.

End-Feel: The normal end-feel was soft because of contact between the muscle bulk of the posterior calf and thigh or between the heel and buttocks. The end-feel may have been firm because of tension in the vastus medialis, vastus lateralis and vastus intermedialis muscles.

Goniometer Alignment: The center of the fulcrum was placed over the lateral epicondyle of the femur. The proximal arm was aligned with the greater

trochanter. The distal arm was aligned with the lateral malleolus and fibular head.

4.) ANKLE DORSIFLEXION

Starting Position: The subject was sitting, with the knee flexed at 90 degrees. The foot was positioned in 0 degrees of inversion and eversion.

Motion: Movement occurred in the sagittal plane around a medial-lateral axis.

End-Feel: The normal end-feel was firm because of tension in the posterior joint capsule, the Achilles tendon, the posterior portion of the deltoid ligament, the posterior talofibular ligament and the calcaneofibular ligament.

Goniometer Alignment: The center of the fulcrum was placed over the lateral aspect of the lateral malleolus. The proximal arm was aligned with the head of the fibula. The distal arm was aligned parallel to the lateral aspect of the fifth metatarsal.

5.) SIT AND REACH TEST

Purpose: To assess hamstring-lumbar flexibility.

Equipment: Sit and reach box (Flexi-Bench manufactured by Health Accessories)

Instructions: The subject sat on the floor with legs extended in front of their body, knees together and feet (with no shoes) flat against the box. The subject's toes were on the 0 inch mark of the box. Both hands were kept palms down, one on top of the other. Knees maintained a fully extended position at all times. The subject slowly reached forward with both hands as far as

possible on the box, holding the position for two seconds. No bouncing was allowed.

Scoring: Three trials were performed. The best of the three were recorded. Measurements were taken to the nearest 0. 5 inch.

Statistical Analysis

Descriptive statistics were used to describe data such as age, weight, height, physical activity level and each ROM measurement. Pearson correlation coefficients were used to correlate flexibility scores to the four physical activity indices. The significance level was set at $p \leq 0.05$.

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS

Table 4 describes the male subjects' characteristics. The males (n=64) ranged in age from 19-52 years. The mean weight and height were 88.8 kg and 178.6 cm, respectively. The mean joint ranges of motion were 177.5 degrees of shoulder flexion (SF), 79.9 degrees of hip flexion (HF), 136.1 degrees of knee flexion (KF), and 13.6 degrees of ankle dorsiflexion (ADF). The males' mean sit and reach score (SR) was 1.8 inches. Finally, the mean physical activity scores for the male subjects included 2.8 for the work index (WI), 3.1 for the sports index (SI), 2.7 for the non-sports, leisure index (LI) and 8.6 for the total physical activity score (TPA).

Table 5 describes the female subjects' characteristics. The females (n=64) ranged in age from 19-53 years. The mean weight and height were 67.2 kg and 165.9 cm, respectively. The mean joint ranges of motion were 183.0 degrees of shoulder flexion (SF), 91.8 degrees of hip flexion (HF), 138.9 degrees of knee flexion (KF) and 15.5 degrees of ankle dorsiflexion (ADF). The females' mean sit and reach score (SR) was 4.4 inches. Finally, the mean physical activity scores for the female subjects included 2.7 for the work index (WI), 2.7 for the sports index (SI), 2.7 for the non-sports, leisure index (LI) and 8.1 for the total physical activity score (TPA).

TABLE 4

Male Subject Characteristics (n=64)

VARIABLE	MEAN	SD	RANGE
Age, yr	28.6	9.2	19.0 – 52.0
Weight, kg	88.8	17.2	58.3 – 150.0
Height, cm	178.6	12.8	95.5 – 195.0
Shoulder Flexion, degrees	177.5	11.3	156.0 – 206.0
Hip Flexion, degrees	79.9	11.0	58.0 – 108.0
Knee flexion, degrees	136.1	6.7	120.0 – 153.5
Ankle Dorsiflexion, degrees	13.6	5.3	1.0 – 27.0
Sit and Reach, inches	1.8	3.6	-6.5 – 10.0
Work Index	2.8	0.8	1.1 – 4.6
Sports Index	3.1	0.7	1.8 – 4.8
Leisure Index	2.7	0.8	1.3 – 4.5
Total Physical Activity Score	8.6	1.2	5.0 – 11.3

TABLE 5

Female Subject Characteristics (n=64)

VARIABLE	MEAN	SD	RANGE
Age, yr	30.8	10.6	19.0 – 53.0
Weight, kg	67.1	14.9	45.9 – 118.3
Height, cm	165.9	6.9	150.0 – 182.0
Shoulder Flexion, degrees	183.0	9.7	163.5 – 206.5
Hip Flexion, degrees	91.8	11.8	54.0 – 116.0
Knee Flexion, degrees	138.9	7.6	118.0 – 153.0
Ankle Dorsiflexion, degrees	15.5	6.2	-4.0 – 26.5
Sit and Reach, inches	4.4	3.3	-6.5 – 12.0
Work Index	2.7	0.8	1.3 – 3.9
Sports Index	2.7	0.8	1.0 – 4.8
Leisure Index	2.7	0.8	1.0 – 4.8
Total Physical Activity Score	8.1	1.8	3.3 – 13.1

Table 6 identifies correlations among the five different flexibility measurements and the various physical activity scores. All of the correlation coefficients were very low. However, three were considered significant with an alpha level set at $p \leq 0.05$. Hip flexion measurements, when compared to the non-sports, leisure index had a correlation coefficient of $r = 0.195$. When sit and reach scores were correlated to the leisure index and total physical activity scores, the resultant correlation coefficients were $r = 0.222$ and $r = 0.208$, respectively.

The five flexibility measurements were combined into one composite score which was termed total flexibility. This was accomplished by converting the raw data into z scores, which then made the correlations possible. Table 7 depicts the correlations total flexibility had to all the variables that were examined throughout this study. Again, low correlation coefficients resulted, with seven being significant. Gender, age and weight had low, negative significant correlation coefficients of $r = -0.400$, $r = -0.188$ and $r = -0.251$, respectively. Shoulder flexion and ankle dorsiflexion measurements had moderate, positive relationships of $r = 0.598$ and $r = 0.479$, respectively. Hip flexion and sit and reach scores had strong, positive correlation coefficients of $r = 0.732$ and $r = 0.776$, respectively. The four physical activity indices had no significant correlation to total flexibility.

TABLE 6

Correlations of Flexibility Measurements
to Physical Activity Scores

	SF	HF	KF	ADF	SR
WI	0.086	-0.006	0.128	-0.061	0.110
SI	0.046	0.110	0.033	-0.055	0.088
LI	-0.020	0.195*	0.138	0.112	0.222*
TPA	0.060	0.147	0.149	-0.005	0.208*

* $p \leq 0.05$

SF = Shoulder Flexion
HF = Hip Flexion
KF = Knee Flexion
ADF = Ankle Dorsiflexion
SR = Sit and Reach
WI = Work Index
SI = Sports Index
LI = Leisure Index
TPA = Total Physical Activity Index

TABLE 7

Correlations of Total Flexibility Measure
to Examined Variables

VARIABLE	CORRELATION
Gender	-0.400*
Age	-0.188*
Weight	-0.251*
Height	-0.143
Shoulder Flexion	0.598*
Hip Flexion	0.732*
Knee Flexion	-0.006
Ankle Dorsiflexion	0.479*
Sit and Reach	0.776*
Work Index	0.000
Sports Index	0.060
Leisure Index	0.143
Total Physical Activity Index	0.101

* $p \leq 0.05$

DISCUSSION

Significant relationships were found between hip flexion and the non-sport, leisure index, sit and reach and the leisure index, and the total physical activity scores. The correlations were r=0.195, r=0.222 and r=0.208, respectively. These are all weak, positive values, but still significant. These results indicate that, in general, the more physically active individuals are, specifically during their leisure time, the better their hip flexion is. Also, the more physically active people are during leisure time, as well as during combined work, sport and leisure time, sit and reach scores tend to be higher. These results are similar to Horowitz and Montgomery (1993), Ford et al. (1989), Caballero et al. (1996) and Voorrips et al. (1993). Horowitz and Montgomery (1993) studied 1,303 subjects comprising of fire fighters and non-fire fighters. After comparing the two groups, they found the fire fighters to be more physically active during a battery of fitness tests. More importantly, their results indicated that the more physically active fire fighters possessed greater sit and reach measurements. Ford et al. (1989) studied 108 college students with an average age of 19.8 years. They used a battery of fitness tests to compare scores before and after an eight week activity course. Students showed an increase in sit and reach scores following classes such as jogging for fitness, aerobic dance, weight training and life saving. Another study conducted by Caballero et al. (1996) investigated the pre- and post-fitness test scores of 19 postmenopausal women who participated in five months of moderate exercise training. One particular finding

was that front and back flexibility, which they measured with a flexibilimeter, increased as a result of the five month exercise period. Voorrips et al. (1993) looked at a group of 50 elderly women with an average age of 71 years. They determined that the more physically active women demonstrated greater hip and spine flexibility which they measured by the sit and reach test.

A low, negative significant relationship, r=-0.251, was found between body weight and the total flexibility score. Specifically in this group of subjects, the heavier individuals were noted to have lower total flexibility scores. The same study by Voorrips et al. (1993) discovered a similar finding with their group of 50 elderly, female subjects. They too noticed that higher body weights had significantly lower flexibility scores in the shoulders, hip and spine.

The present study also noted that relationships existed between age and total flexibility, as well as gender and total flexibility. The results demonstrated that as age increased, total flexibility decreased significantly. Data were analyzed be designating females as 0 and males as 1. A negative, significant relationship was the outcome of gender and this total flexibility score, meaning that in this group of subjects, the females tended to have the better total flexibility scores. Although both of these concepts are thought to be true by health and fitness professionals, no research was found to support this. One may speculate that in the case of weight and total flexibility, the amount of fat tissue an individual has may act as a limiting factor when moving their joints through the full range of motion. Possibly, the less fat tissue an individual may have, the greater the

joint ROM. It can also be speculated that the anatomical differences between men and women, for example women having wider hips and more moveable, elastic joints may be the reason for women having more total flexibility scores than men.

Other positive, moderate to strong significant relationships were also found to exist when shoulder flexion, ankle dorsiflexion, hip flexion and sit and reach scores when each were correlated to total flexibility. This indicated that in this group of subjects, the greater the total flexibility was, the greater shoulder flexion, ankle dorsiflexion and hip flexion they would possess, as well as a better sit and reach score. Again, no research was found that could support these observations.

Numerous relationships were found to be statistically significant, however, the majority of these were weak. It was not easy to compare the results of this study to the limited research, which tends to state general findings. It is important to keep in mind that this study is unique in that it examined the relationship between flexibility and physical activity levels, as well as carefully choosing subjects who did not stretch on a regular basis. Narrowing subject selection in this manner may have caused this study to focus on a homogeneous group, therefore weakening the correlations between the measured variables and rejecting the hypothesis of the study. Future studies should focus on studying a more diverse group of subjects, possibly older in age and including those who stretch on a regular basis.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The purpose of this study was to determine if a relationship existed between flexibility and physical activity levels. Subjects included 128 male (n=64) and female (n=64) volunteers, 19 to 55 years of age, of various physical activity levels and specifically those who had not participated in a regular stretching program for the past six months. Those who were not eligible to participate were those pregnant or post-partum women, those experiencing joint swelling at the time of testing or who had any musculoskeletal injuries or surgeries within the past six months. It was hypothesized that a positive relationship would exist between physical activity levels and flexibility measurements although individuals were not performing regular stretching programs.

Subjects completed a one page, physical activity questionnaire, a warm-up by walking for eight minutes at a self-selected pace, followed by a series of five flexibility tests. Demographic information included gender, age, weight and height. Four of the five flexibility tests were completed with the use of a goniometer which measured the range of motion for the following joints and motions: shoulder flexion, hip flexion, knee flexion and ankle dorsiflexion. The other flexibility measure was the sit and reach test used to assess hamstring-lumbar flexibility. The tests were performed in random order.

After analyzing the data by using correlational statistics, a relationship did not exist between total flexibility and any of the four physical activity indices. Ten significant relationships were discovered, however, they were primarily weak in strength. Hip flexion measures, when correlated to the leisure physical activity index had a correlation coefficient of $r = 0.195$. Sit and reach correlated to the leisure index and total physical activity ($r = 0.222$ and $r = 0.208$, respectively).

Furthermore, this study found that the subjects that weighed more had lower total flexibility ($r = -0.251$). This group of subjects also demonstrated that as age increased, total flexibility decreased significantly ($r = -0.188$), and the females tended to have better total flexibility scores versus the males ($r = -0.400$). Those subjects with the greater total flexiblity had more shoulder flexion, ankle dorsiflexion, hip flexion and better sit and reach scores ($r = 0.598$, $r = 0.479$, $r = 0.732$ and $r = 0.776$, respectively).

CONCLUSION

In conclusion, the group of subjects that participated in this study demonstrated that physical activity (whether it was on the job, during leisure time, taking part in an organized sport or all three indices combined) did not correlate to the amount of total flexibility they possessed. It should be noted that measures were taken to control for the utilization of subjects who were not previously taking part in regular stretching programs. However, it was found that those who had greater total physical activity levels had better sit and reach scores. Also, those who performed more leisure time physical activity

demonstrated greater hip flexion, as well as sit and reach scores. This study also concluded that subjects who were either younger, female or lower in body weight tended to have better total flexibility. One final observation from this study was that those with better total flexibility had greater shoulder flexion, hip flexion, ankle dorsiflexion and sit and reach scores.

RECOMMENDATIONS

Further research is needed to assess what specifically influences flexibility, as well as why and to what extent. Age, gender and joint specific norms for range of motion need to be better established with a variety of tools such as the goniometer or flexometer. Finally, longitudinal studies looking at the relationship between flexibility, age and physical activity levels need to be researched to better understand how age effects these variables. Many facts are assumed regarding flexibility with little research to support these assumptions.

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APPENDIX A

ADULT CONSENT FORM

University of Nebraska at Omaha

School of Health, Physical Education and Recreation
Omaha, Nebraska 68182-0216
(402) 554-2670

IRB # 172-98

ADULT INFORMED CONSENT FORM

THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND FLEXIBILITY

INVITATION TO PARTICIPATION

You are invited to participate in this research study. The following information is provided in order to help you to make an informed decision whether or not to participate. If you have any questions please do not hesitate to ask.

BASIS FOR SUBJECT SELECTION

You are eligible to participate in this study because you are a male or female between the ages of 19-55 years. You are also eligible to participate because you are not pregnant or post-partum, experiencing joint swelling at this time, or have had any musculoskeletal injuries or surgeries within the past six months. You may participate only if you have not participated in a regular stretching program for the past six months prior to this study. No physical activity should be performed on your scheduled day prior to testing.

PURPOSE OF THE STUDY

The purpose of this study is to determine if a relationship exists between flexibility measurements and physical activity levels.

EXPLANATION OF PROCEDURES

You will be asked to come to the Exercise Physiology Laboratory at the University of Nebraska at Omaha to participate in a one-time session. During this session you will complete a one page, physical activity questionnaire, as well as warm-up by walking for eight minutes at a self-selected pace, followed by a series of five flexibility tests. For the purpose of subject demographics, gender, age, weight and height will be recorded.

Four of the five flexibility tests will be completed with the use of a goniometer which will measure the range of motion for the following joints and motions: shoulder flexion, hip flexion, knee flexion and ankle dorsiflexion. The other test will be the sit and reach test to assess hamstring-lumbar flexibility. The order of the tests you perform will be determined randomly.

POTENTIAL RISKS AND DISCOMFORTS

There are minimal risks associated with all flexibility tests which include and are not limited to muscle pulls and strains, and delayed muscle soreness.

Initials

University of Nebraska at Omaha

School of Health, Physical Education and Recreation
Omaha, Nebraska 68182-0216
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POTENTIAL BENEFITS TO THE SUBJECTS

You will obtain information regarding your flexibility levels and how they compare to the normative data. Also, you will obtain feedback about the score you receive from the Baecke Questionnaire of Habitual Physical Activity.

POTENTIAL BENEFITS TO SOCIETY

Exercise and health professionals may benefit by learning more about the relationship between physical activity and flexibility. Information gained from this study might explain if being more physically active on the job and during leisure-time is enough to maintain the normal amounts of joint range of motion, or if a daily stretching program is necessary. Additionally, this study will contribute to the limited amount of research presently available on the topic of flexibility.

IN CASE OF EMERGENCY CONTACT PROCEDURE

In the event of a research related injury or if you experience an adverse reaction please immediately contact one of the investigators listed at the end of this consent form.

EMERGENCY CARE AND COMPENSATION IN CASE OF INJURY

In the unlikely event that you should suffer an injury as a direct consequence of the research procedures described above, the medical care required to treat the injury will be provided by the University of Nebraska at Omaha at no expense to you, providing that the cost of such medical care is not reimbursable through your own health insurance. However, no additional compensation for loss of income, pain and suffering or any other form of compensation will be provided as a result of such injury and any subsequent medical care, including hospitalization. None of the above shall be construed as a waiver of any legal rights or redress you may have.

FINANCIAL OBLIGATIONS

No fee will be charged for participation in this study.

ASSURANCE OF CONFIDENTIALITY

Information obtained from you during this study will be treated confidentially. Your name will not be used in the publishing of the results of this study. Only group data will be reported.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigators or the University of Nebraska at Omaha. Your decision will not result in loss of benefits to which you are otherwise entitled. If any

IRB APPROVED
VALID UNTIL 5/10/95

Initials

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information develops or changes occur during the course of this study that may affect your willingness to continue participating you will be informed immediately.

RIGHTS OF RESEARCH SUBJECTS

Your rights as research subjects have been explained to you. If you have any additional questions concerning the rights of research subjects, you may contact the University of Nebraska Institutional Review Board (IRB), telephone (402) 559-6463.

DOCUMENTATION ON INFORMED CONSENT

YOU ARE VOLUNTARILY MAKING A DECISION WHETHER OR NOT TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE CERTIFIES THAT THE CONTENT AND MEANING OF THE INFORMATION ON THIS CONSENT FORM HAVE BEEN FULLY EXPLAINED TO YOU AND THAT YOU HAVE DECIDED TO PARTICIPATE HAVING READ AND UNDERSTOOD THE INFORMATION PRESENTED. YOUR SIGNATURE ALSO CERTIFIES THAT YOU HAVE HAD ALL YOUR QUESTIONS ANSWERED TO YOUR SATISFACTION. IF YOU THINK OF ANY ADDITIONAL QUESTIONS DURING THIS STUDY, PLEASE CONTACT THE INVESTIGATORS. YOU WILL BE GIVEN A COPY OF THIS CONSENT FORM TO KEEP.

_____ _____

Signature of Subject **Date**

IN MY JUDGEMENT THE SUBJECT IS VOLUNTARY AND KNOWINGLY GIVING INFORMED CONSENT AND POSSESSES THE LEGAL CAPACITY TO GIVE INFORMED CONSENT TO PARTICIPATE IN THIS RESEARCH STUDY.

_____ _____

Signature of Investigator **Date**

5/9/97

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APPENDIX B

MEDICAL HISTORY FORM

HEALTH HISTORY QUESTIONNAIRE

Name_____ Date_____

Address_____ Phone_____

Gender_____ Height_____ Weight_____ Age_____

To help us determine if you can participate in this study, please read the following questions carefully and answer each one honestly. All information will be kept confidential.

YES	NO	
❑	❑	1. Do you have a heart condition? Please explain._____ _____
❑	❑	2. Do you have high blood pressure?
❑	❑	3. Have you ever experienced a stroke?
❑	❑	4. Do you have epilepsy?
❑	❑	5. Do you have diabetes?
❑	❑	6. Do you have asthma?
❑	❑	7. Do you have emphysema?
❑	❑	8. Are you experiencing lower back pain?
❑	❑	9. Have you had a bone, joint or muscle injury that restricted you from engaging in physical activity within the past 6 months?
❑	❑	10. Have you had a musculoskeletal surgery within the past 6 months?
❑	❑	11. Are you currently experiencing swelling in any joint?
❑	❑	12. Are you currently pregnant or post-partum?
❑	❑	13. In the past 6 months, have you participated in a regular stretching program (minimum of once a week)?
❑	❑	14. Are you currently taking any medications? Please list the medications and its purpose._____

15. What is your occupation?_____

16. What types of leisure-time physical activity do you enjoy?

❑ Walk/Jog ❑ Cycling ❑ Aerobic Dance
❑ Swimming ❑ Weight Training ❑ Sports
❑ Other_____
_____

APPENDIX C

BAECKE QUESTIONNAIRE OF HABITUAL PHYSICAL ACTIVITY

Baecke Questionnaire of Habitual Physical Activity

1. What is your main occupation?
   _____ 1-3-5

2. At work I sit
   never / seldom / sometimes / often / always _____ 1-2-3-4-5

3. At work I stand
   never / seldom / sometimes / of ten / always _____ 1-2-3-4-5

4. At work I walk
   never / seldom / sometimes / often / always _____ 1-2-3-4-5

5. At work I lift heavy loads
   never / seldom /sometimes / often / always _____ 1-2-3-4-5

6. After working I am tired
   very often / often / sometimes / seldom / never _____ 5-4-3-2-1

7. At work I sweat
   very often / often / sometimes / seldom / never _____ 5-4-3-2-1

8. In comparison with others my own age, I think my work is physically
   much heavier / heavier / as heavy / lighter / much lighter _____ 5-4-3-2-1

9. Do you play sport?
   yes / no
   If yes:
   -which sport do you play most frequently? _____ Intensity 0.76-1.26-1.76
   -how many hours a week? _____<1/1-2/2-3/3-4/>4 Time 0.5-1.5-2.5-3.5-4.5
   -how many months a year? _____ <1/1-3/4-6/7-9/>9 Proportion 0.04-0.17-0.42-0.67-0.92

   If you play a second sport:
   -which sport do you play most frequently? _____ Intensity 0.76-1.26-1.76
   -how many hours a week? _____ <1/1-2/2-3/3-4/>4 Time 0.5-1.5-2.5-3.5-4.5
   -how many months a year? _____ <1/1-3/4-6/7-9/>9 Proportion 0.04-0.17-0.42-0.67-0.92

10. In comparison with others my own age I think my physical activity during leisure time is
    much more / more / the same / less / much less _____ 5-4-3-2-1

11. During leisure time I sweat
    very ofter / often / sometimes / seldom / never _____ 5-4-3-2-1

12. During leisure time I play sport
    never / seldom / sometimes / of ten / very often _____ 1-2-3-4-5

13. During leisure time I watch television
never / seldom / sometimes / often / very often _____ 1-2-3-4-5

14. During leisure time I walk
never / seldom / sometimes / often / very often _____ 1-2-3-4-5

15. During leisure time I cycle
never / seldom / sometimes / often / very often _____ 1-2-3-4-5

16. How many minutes do you walk and/or cycle per day to and from work, school and shopping?
<5/5-15/15-30/30-45/>45 _____ 1-2-3-4-5